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OF

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FOR A

METHOD AND APPARATUS FOR STRETCHING AND MOUNTING A SCREEN PRINTING SCREEN

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METHOD AND APPARATUS FOR STRETCHING AND MOUNTING A SCREEN PRINTING SCREEN

BACKGROUND OF THE INVENTION

1. FIELD OF THE INVENTION

The present invention generally relates to a method and apparatus for use within a screen printing type operation. In particular, the invention relates to a method and apparatus for tensioning and mounting a screen in separate directions on a dual frame system to be used in screen printing.

2. DESCRIPTION OF THE RELATED ART

Screen printing utilizes a tensioned screen or mesh mounted on a frame having a stenciled image thereon. Ink is applied through the screen in the areas where the stencil has not blocked the openings between the threads of the mesh. The screen/mesh is typically fixed onto a rectangular (sometimes square) frame. Screen/mesh printing is highly variable in nature, with one of the main causes being the tension variation across a screen/mesh simultaneously stretched in two directions, either immediately, or due to variable tension loss over time. The variation in tensioning forces also affects the regular nature of the woven screen/mesh structure, causing variation in screen/mesh opening sizes, and ink/fluid transfer rates. To attempt to address this systems are available for multi-stage screen/mesh stretching, to retension the screen/mesh after use, in an attempt to increase

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stability and consistency over time and use. However, these systems increase the cost of producing a stable and consistent screen printed product, and each time the screen/mesh is used it risks damage and loss. Screen/mesh is typically supplied on rolls for multiple applications and, to a very limited extent, pre-coated with stencil materials. The rolls are often large, difficult to handle, and liable to impact damage. Stretching systems for screen printing are highly variable in the range of mechanisms and techniques used.

A conventional screen/mesh stretching and mounting process is illustrated in **Figs. 1-4**. A screen/mesh is initially clamped **10** and stretched **12** in two directions. A single frame is then moved **14** to contact the screen/mesh. The single frame is then fixed to the screen/mesh permanently or via retensionable side mechanisms **16**. Excess screen/mesh is then trimmed and the screen/mesh is then ready for imaging and use **18**.

Once the screen/mesh is attached to the single frame resistive forces to deflection are applied under a squeegee action in the plain of the screen/mesh stretching. This is particularly true the nearer to the frame the squeegee travels. This results in variation in the squeegee deflection and screen/mesh contact across the width of the print image and perpendicular to the print direction. To address this squeegee action deflection forces are increased to ensure contact at the ends of the print area, which results in excess squeegee pressure and deflection at the center of the print image, causing

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increased squeegee wear, possible screen/mesh damage, and/or variation of ink and/or fluid transfer across the print width.

Once printing is complete, unless the screen/mesh is to be reused for the same print job, the stretched screen/mesh will be reclaimed by removal of the stencil material using harsh chemicals and/or high pressure water jets. This is a time consuming and costly process, only justified by the high screen/mesh preparation cost, and improved screen/mesh stability over time with the conventional single frame screen/mesh printing process. The screen/mesh reclamation is also potentially harmful to the environment, due to the need to use chemicals, water, and energy to remove the stencil, along with significant disposal issues for the remaining chemicals, stencil components, inks/fluids, and water remaining at the end of the process.

Therefore, a need exists for a method and apparatus for stretching and mounting a screen printing screen that assures reliable printing qualities, while offering the potential of a simplified production system by achieving disposable screen printing with woven screen/mesh materials.

The related art is represented by the following references of interest.

U.S. Patent Application Publication No. 2002/0061953 A1, published on April 3, 2003 for Thomas R. Bruckl et al., describes a device for drawing a printing material web into a rotary printing press. The Bruckl et al. application does not suggest a method and apparatus for stretching and mounting a screen printing screen according to the claimed invention.

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U.S. Patent No. 2,608,750, issued on September 2, 1952 to Albert C. Cluzel, describes an apparatus for and a method of making printing screens. The Cluzel patent does not suggest a method and apparatus for stretching and mounting a screen printing screen according to the claimed invention.

U.S. Patent No. 2,759,217, issued on August 21, 1956 to Albin K. Peterson, describes a stretching apparatus for forming thick sheets into thinner sheets. The Peterson patent does not suggest a method and apparatus for stretching and mounting a screen printing screen according to the claimed invention.

U.S. Patent No. 3,315,301, issued on April 25, 1967 to Harold J. Dibblee et al., describes an apparatus for universally stretching and forming sheet material. The Dibblee et al. patent does not suggest a method and apparatus for stretching and mounting a screen printing screen according to the claimed invention.

U.S. Patent No. 3,361,612, issued on January 2, 1968 to Francis W. Rowbottam, describes an apparatus for installing screening from a roll onto framing having marginal edges provided with a fusible material. The Rowbottam patent does not suggest a method and apparatus for stretching and mounting a screen printing screen according to the claimed invention.

U.S. Patent No. 4,186,660, issued on February 5, 1980 to John W. Key, describes a screen printing frame with plastic side bars bondable to fabric by surface softening. The Key patent does not suggest a method and apparatus for stretching and

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mounting a screen printing screen according to the claimed invention.

U.S. Patent No. 4,430,815, issued on February 14, 1984 to Stanley S. Wulc, describes a screen printing apparatus which includes a frame to which will be attached to the edge portions of a screen fabric. The Wulc patent does not suggest a method and apparatus for stretching and mounting a screen printing screen according to the claimed invention.

U.S. Patent No. 4,978,414, issued on December 18, 1990, U.S. Patent No. 5,096,524, issued on March 17, 1992, Great Britain Patent Application Publication No. GB 2 171 053 A, published on August 20, 1986, and Germany Patent Application Publication No. DE 3 601 167 A1, published on December 18, 1990, for Yasuaki Ohtani et al., describe an automatic silk stretching apparatus for stretching silk on a silk screen printing frame. The Ohtani et al. '414 and '524 patents, the Great Britain '053 application, and the Germany '167 application do not suggest a method and apparatus for stretching and mounting a screen printing screen according to the claimed invention.

U.S. Patent No. 5,063,842, issued on November 12, 1991 to Joseph Clarke, describes a screen tensioning and framing device. The Clarke patent does not suggest a method and apparatus for stretching and mounting a screen printing screen according to the claimed invention.

U.S. Patent No. 5,136,797, issued on August 11, 1992 to Greg A. Hildebrandt, describes a frame having shiftable bars with flexible ends for securing fabric using adhesive. The

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Hildebrandt patent does not suggest a method and apparatus for stretching and mounting a screen printing screen according to the claimed invention.

U.S. Patent No. 5,271,171, issued on December 21, 1993 to David C. Smith, describes a stretching frame for a fabric material that provides for spring mounting of the four frame sides. The Smith patent does not suggest a method and apparatus for stretching and mounting a screen printing screen according to the claimed invention.

U.S. Patent No. 5,522,148, issued on June 4, 1996 to Donald E. Newman, describes a registration/adapter apparatus for aligning a printing screen with an image platform. The Newman patent does not suggest a method and apparatus for stretching and mounting a screen printing screen according to the claimed invention.

U.S. Patent No. 5,581,918, issued on December 10, 1996 to Christian Schilling et al., Germany Patent Application Publication No. DE 4 437 503 A1, published on May 4, 1995, and European Patent Application No. EP 0 650 832 A1, published on May 3, 1995, describe an apparatus for stretching out a rectangular material in a printing frame with tensioning devices which are arranged at the sides thereof. The Schilling et al. patent, the Germany '503 application, and the European '832 application do not suggest a method and apparatus for stretching and mounting a screen printing screen according to the claimed invention.

U.S. Patent No. 5,598,776, issued on February 4, 1997 to Slobodan Casl, describes a screen printing apparatus which is

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tensionable. The Casl patent does not suggest a method and apparatus for stretching and mounting a screen printing screen.

U.S. Patent No. 5,937,751, issued on August 17, 1999 to Eugene F. Newman, Jr., describes a screen printing frame and bordered fabric stretching devices for quickly stretching and for retensioning a screen. The Newman, Jr. '751 patent does not suggest a method and apparatus for stretching and mounting a screen printing screen according to the claimed invention.

U.S. Patent No. 6,070,526, issued on June 6, 2000 to James D. Larson, describes a tensioning system for use in a retensionable frame used in silk screening wherein the fabric is precut and bordered with splines such that the appropriate tension is predetermined. The Larson patent does not suggest a method and apparatus for stretching and mounting a screen printing screen according to the claimed invention.

U.S. Patent No. 6,435,085 B1, issued on August 20, 2002 to James A. York, describes a print screen frame used in the textile screen print industry. The York patent does not suggest a method and apparatus for stretching and mounting a screen printing screen according to the claimed invention.

U.S. Patent No. 6,561,089 B1, issued on May 13, 2003 to Eugene F. Newman, Jr., describes a screen assembly with border strips already adhered to fabric in precisely measured locations along each edge of the screen fabric. The Newman, Jr. '089 patent does not suggest a method and apparatus for stretching and mounting a screen printing screen according to the claimed invention.

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Germany Patent Application Publication No. DE 3 533 269 A1, published on March 26, 1987, describes a screen printing frame having a rectangular frame opening bounded by four frame sections for technical and graphic printing. The Germany '269 application does not suggest a method and apparatus for stretching and mounting a screen printing screen according to the claimed invention.

Great Britain Patent Application Publication No. GB 2 195 129 A, published on March 30, 1988, describes a screen stretching and securing frame. The Great Britain '129 application does not suggest a method and apparatus for stretching and mounting a screen printing screen according to the claimed invention.

Great Britain Patent Application Publication No. GB 2 272 863 A, published on June 1, 1994, describes a screen printing apparatus that includes a screen frame which supports a screen of natural or artificial fabric or metal mesh, a squeegee to force ink through unsealed portions of the screen, and a tunnel supplied with heated air for drying workpieces fed on a transporting belt. The Great Britain '863 application does not suggest a method and apparatus for stretching and mounting a screen printing screen according to the claimed invention.

None of the above inventions and patents, taken either singly or in combination, is seen to describe the instant invention as claimed. Thus a method and apparatus for stretching and mounting a screen printing screen solving the aforementioned problems is desired.

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SUMMARY OF THE INVENTION

The present invention is a method and apparatus for stretching and mounting a screen printing screen. The apparatus generally includes a dual frame system for separating and supporting the tensioning forces on a screen printing screen/mesh in two directions. Significant tension forces are applied in the print direction, while the perpendicular forces are lower and less significant. The inner frame provides a support barrier type mechanism(s) for ink/fluid retention on the screen/mesh for controlled transfer during the printing action.

The system provides a method of achieving controlled and consistent screen properties for new or reused screen/mesh materials. The system is applicable for use with conventional woven screen/mesh materials in a disposable, as well as reusable, screen printing system. The separation of the tension forces also simplifies press setup and operation, by reducing the two directional tensioning forces, and resistance on the screen deflection to a minimum.

Accordingly, it is a principal aspect of the invention to provide a method for stretching and mounting a screen printing screen that provides an outer frame, provides an inner frame, provides a screen/mesh with two print direction sides and two ends, clamps an end of the screen/mesh in a print direction, applies significant tension forces to the screen/mesh in the print direction, moves the outer frame to contact the stretched screen/mesh, attaches the screen/mesh to the outer frame in the

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print direction, trims excess screen/mesh in the print direction, moves the inner frame to contact the screen/mesh, attaches the screen/mesh to the inner frame in the print direction, and provides imaging/printing on the screen/mesh.

It is another aspect of the invention to provide an apparatus for stretching and mounting a screen printing screen, the apparatus including an inner frame with a support barrier mechanism for ink/fluid retention on a screen for controlled transfer during a printing period, and an outer frame configured for placing outside the inner frame, wherein the inner and outer frames do not connect, support or constrain each other to provide tension and ink barrier functions, and significant tension forces are applied in a print direction.

It is an aspect of the invention to provide improved elements and arrangements thereof in a method and apparatus for stretching and mounting a screen printing screen for the purposes described which is inexpensive, dependable and fully effective in accomplishing its intended purposes.

These and other aspects of the present invention will become readily apparent upon further review of the following specification and drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 shows steps involved in a conventional screen/mesh printing stretching process.

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Fig. 2 illustrates the effects of two directional forces in a conventional screen/mesh stretching process.

Fig. 3 illustrates the effect of two directional stretching in a conventional screen/mesh stretching process.

Fig. 4 illustrates the useable area against waste area of a screen/mesh in a conventional two directional stretching process.

Fig. 5 illustrates steps involved in a screen/mesh stretching process according to the present invention.

Fig. 6 shows a screen/mesh mounted on an outer frame following print direction stretching according to the present invention.

Figs. 7A, 7B, 7C, 7D, 7E, and **7F** illustrate alternative print direction stretching techniques according to the present invention.

Figs. 8A, 8B, and **8C** illustrate print direction tensioning techniques according to the present invention.

Figs. 9A, 9B, 9C, and **9D** are stretching steps according to the present invention.

Fig. 10 is a frame system using adhesive tape according to the present invention.

Figs. 11A and **11B** illustrate a rotatable fixed weight according to the present invention.

Figs. 12A, 12B, and **12C** are lateral pre-stretching techniques according to the present invention.

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Fig. 13 is a frame adjustable in x and y directions according to the present invention.

Fig. 14A illustrates a screen/mesh and print direction forces to be applied before print direction stretching according to the present invention.

Fig. 14B illustrates a screen/mesh and print direction forces present after print direction stretching according to the present invention.

Fig. 15A is a screen/mesh tensioned and fixed to an outer frame in the print direction according to the present invention.

Fig. 15B is a fixed inner frame according to the present invention.

Fig. 15C is a four piece inner frame according to the present invention.

Figs. 16A and **16B** are side views of ink/fluid barriers according to the present invention.

Fig. 17 is a perspective view of ink/fluid barriers according to the present invention.

Fig. 18 illustrates ink/fluid barriers according to the present invention.

Fig. 19 illustrates interlocking connector pieces for a multi-piece frame system according to the present invention.

Figs. 20A and **20B** are a multi-piece system according to the present invention.

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Fig. 21 illustrates an end piece, a corner piece, and a side piece of an interlocking fixed frame according to the present invention.

Fig. 22 is a tool with two prongs that allows simultaneous removal of two lugs from a corner piece of an interlocking fixed frame according to the present invention.

Fig. 23A is a cross sectional view of a side piece of an interlocking frame according to the present invention.

Fig. 23B is a cross sectional view of an end piece of an interlocking frame according to the present invention.

Fig. 24 is a perspective view of a side piece of an interlocking frame according to the present invention.

Fig. 25A is a perspective view of a corner piece of an interlocking frame according to the present invention.

Fig. 25B is cross sectional view of a corner piece of an interlocking frame according to the present invention.

Fig. 25C is a top view of a flexible corner piece of an interlocking frame according to the present invention.

Fig. 26A is a top view of pieces of an interlocking frame according to the present invention.

Fig. 26B are cross sectional side view an ink barriers according to the present invention.

Fig. 26C is a cross sectional side view of an end piece with an interconnecting piece according to the present invention.

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Fig. 26D is a cross sectional side view of an end piece with an interconnecting piece according to the present invention.

Fig. 27A is a top view of end frame pieces before displacement of the end frame pieces according to the present invention.

Fig. 27B is a top view of end frame pieces after displacement of the end frame pieces according to the present invention.

Fig. 28 is a top perspective view of a lock piece according to the present invention.

Fig. 29 is a cross sectional side view of a lock piece according to the present invention.

Fig. 30 is a cross sectional side view of a mechanism allowing the forcing apart of pieces of an interlocking frame according to the present invention.

Fig. 31A is a top view of an inner frame side piece according to the present invention.

Fig. 31B is a side view of an inner frame side piece according to the present invention.

Fig. 32A is a top view of an inner frame cross support according to the present invention.

Fig. 32B is a side view of an inner frame cross support according to the present invention.

Fig. 33A is a top view of an inner frame end piece according to the present invention.

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Fig. 33B is a side view of an inner frame end piece according to the present invention.

Fig. 34A is a top perspective view of an end of an inner frame according to the present invention.

Fig. 34B is a top perspective view of an end of an inner frame according to the present invention.

Fig. 34C is a top perspective view of an inner frame support clip according to the present invention.

Fig. 35 is a top perspective view of inner frame parallel guide components according to the present invention.

Fig. 36 is a top perspective view of an inner frame side piece with a profiled end according to the present invention.

Fig. 37 is a top view of an inner frame side piece with a profiled end according to the present invention.

Figs. 38A and **38B** are top and side views of a screen/mesh following print direction stretching according to the present invention.

Figs. 39A and **39B** are top and side views of an inner frame placed on a print direction stretched screen/mesh according to the present invention.

Figs. 40A and **40B** are top and side views of an inner frame fixed in position on a stretched screen/mesh according to the present invention.

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Figs. 41A and **41B** are top and side views of an inner frame fixed in position with end pieces fitted in location on a stretched screen/mesh according to the present invention.

Fig. 42 illustrates lower level tension forces perpendicular to the print direction on a screen/mesh before inner frame mounting according to the present invention.

Fig. 43 illustrates a deflected screen/mesh following the fitting of inner frame end pieces according to the present invention.

Figs. 44A and **44B** are top and side views of an inner frame with inner frame cross supports removed and the end pieces locked into position with locking clips on a screen/mesh according to the present invention.

Figs 45A and **45B** are top and side views of an inner frame on a screen/mesh illustrating the potential image area available according to the present invention.

Figs. 46A and **46B** are top and side views of an inner frame on a screen/mesh, where ink barriers are applied to all four sides of the inner frame according to the present invention.

Fig. 47A is a top perspective view of a single-piece inner frame ink/fluid barrier structure according to the present invention.

Fig. 47B is a top view of the single-piece inner frame ink/fluid barrier structure shown in **Fig. 47A**.

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Fig. 48 is a top perspective view of an example of a corner structure of the inner frame ink/fluid barrier structure shown in **Figs. 47A** and **47B**.

Fig. 49 is a cross sectional side view of a portion of an ink/fluid barrier on a screen/mesh according to the present invention.

Fig. 50 shows ink/fluid barrier structures according to the present invention.

Figs. 51A, **51B**, **51C**, and **51D** illustrate various screen/mesh formats according to the present invention.

Fig. 52 is a screen/mesh with support strips according to the present invention.

Fig. 53 illustrates plural screen/meshes with protective separator layers according to the present invention.

Similar reference characters denote corresponding features consistently throughout the attached drawings.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

The present invention is a method and apparatus for stretching and mounting a screen printing screen. The invention disclosed herein is, of course, susceptible of embodiment in many different forms. Shown in the drawings and described herein below in detail are preferred embodiments of the invention. It is to be understood, however, that the present disclosure is an

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exemplification of the principles of the invention and does not limit the invention to the illustrated embodiments.

Screen printing according to the present invention separates tension forces into a major and a minor set and greatly reduces the variation of tension forces during the stretching process, allowing highly consistent screens to be produced each and every time. The method of stretching and mounting a screen printing screen is achieved in two single and separate stretching process stages which accelerate the screen printing process, reduces the potential variables, and eliminates the variation due to the two directional stretching processes combined with the screen use. The use of existing fixed or retensioning frames as the outer frame allows its implementation, as an option in all existing, as well as new screen printing companies. The attachment of an inner frame to the side edges of a screen/mesh increases stability and support for image quality, while also providing a means to attach single or multi-part barriers to contain the ink/fluid within the printing area of the screen/mesh, allowing the inventive screen printing process to be used within existing presses and printing companies.

A method for stretching and mounting a screen printing screen according to the invention provides an outer frame, provides an inner frame, and provides a screen/mesh with two print direction sides and two ends. An end of the screen/mesh is clamped in a print direction. Significant tension forces are applied to the clamped screen/mesh in the print direction. The outer frame is moved to contact the stretched screen/mesh, and

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the screen/mesh is attached to the outer frame. The inner frame is moved to contact the screen/mesh, and the screen/mesh is attached to the inner frame. Imaging/printing is provided on the screen/mesh.

An apparatus for stretching and mounting a screen printing screen according to the invention includes an inner frame with a support barrier mechanism for ink/fluid retention on a screen/mesh for controlled transfer during a printing period, and an outer frame configured for placing outside the inner frame. The inner and outer frames do not connect, support or constrain each other to provide tension and ink barrier functions, and significant tension forces are applied to the screen/mesh in a print direction.

Fig. 5 shows steps involved in a screen/mesh stretching process according to the invention. While the screen/mesh material is preferably made and/or woven of polyester, the screen/mesh material may alternatively be made and/or woven of silk, nylon, etc. The screen/mesh is clamped in one direction, the print direction **40**. The screen/mesh is then stretched in the print direction **42**. A frame is then moved to contact the screen/mesh **44**. The frame is fixed to the screen/mesh permanently or via retensionable side mechanisms **46**. Excess screen/mesh in the print direction is then trimmed and the screen/mesh is then ready for attaching to an inner frame **48**. **Fig. 6** shows the screen/mesh **54** mounted on the outer frame **52**

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following the print direction stretching steps shown in **Fig. 5**. The ends of the screen/mesh **56** are fixed to the outer frame **52**.

Fig. 7A shows a simple pulling system **60** with equal and opposite pulling forces applied to a screen/mesh to apply the print direction tension to the screen/mesh. **Fig. 7B** shows a simple pulling system **62** where one end of a screen/mesh is fixed and the other end is pulled to apply the print direction tension to the screen/mesh. **Fig. 7C** shows a gravity pulling system **64** where two equal gravity loads are applied to the ends of a screen/mesh and to facilitate easy print direction movement of a screen/mesh. **Fig. 7D** shows a gravity pulling system **66** where one end of a screen/mesh is fixed and a single load is applied to the other end of the screen mesh. **Fig. 7E** shows a system **68** which relies on the use of self adhesive tape to fix the screen/mesh to the frame before tensioning. The screen/mesh is attached to the frame at one end, and then the frame is rotated into position to allow attachment of the tensioned screen/mesh. **Fig. 7F** shows a system **70** similar to the system **68** except the support roller is lowered to bring the tensioned screen/mesh into contact with the frame.

Figs. 8A, **8B**, and **8C** show print direction tensioning techniques of the present invention. The screen/mesh is initially precut to the correct width of an outer frame and the ends of the screen/mesh is clamped **80**. The screen/mesh may be

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stretched by using equal loads applied to both ends **82**, or stretching each end outwards **84**. **Fig. 9A** shows tension forces being applied to the ends of a screen/mesh **90**. **Fig. 9B** shows a frame being moved into contact with a strained screen/mesh **92**. **Fig. 9C** shows tension forces being applied to the screen/mesh while the frame is attached to the screen/mesh **94**. **Fig. 9D** shows the screen/mesh after being trimmed once the tension forces are removed from the ends of the screen/mesh **96**.

Fig. 10 shows an adhesive system **100** where the frame support is attached to a screen/mesh via adhesive. Initially, fixed masses are applied to the ends of the screen/mesh and cause a controlled tension force to be applied to the screen/mesh. The frame support is then raised to bring adhesive on the top of the frame into contact with the screen/mesh. Mass supports are then raised for each of the fixed masses to remove the tension forces applied to the screen/mesh. The excess screen/mesh is then cut/trimmed from the screen/mesh outside of the frame. The frame is then removed with the screen/mesh tensioned in the print direction. **Figs. 11A** and **11B** illustrate how the fixed weights may be attached with rotatable clamps to ensure free motion of the weights in all directions when they are attached and apply tension forces to the screen/mesh.

Referring to **Figs. 12A-12C**, screen/mesh lateral pre-stretching for print direction tensioning begins by clamping an area of the screen/mesh and applying a low level lateral

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tension to the screen/mesh **110**. Once low level lateral tension is applied, the screen/mesh is clamped for print direction tensioning. Once clamped the lateral tension has little effect and can be released. Alternatively, two side corners of the screen/mesh may be fixed and tension may be applied in one direction **112**. Alternatively, tension may be applied equally to both sides of the screen/mesh **114**.

Outer frame positioning for individual screen/mesh samples is shown in **Fig. 13**. For introduction of individual screen/mesh samples, particularly with pre-coated stencil areas, the position of the screen/mesh to the frame is critical to print consistency. The print direction stretching controls the correct positioning of the screen/mesh. Existing systems do not require the frame to move in the print or lateral directions for screen/mesh positioning. The apparatus according to the present invention may include an x-y adjustable table below the frame to allow repositioning of the frame relative to the stretched screen/mesh **120**. The x-y table may be manually, mechanically, and/or automatically activated. With an x-y table the frame may be moved relative to the screen/mesh in x and y directions. Once the frame is positioned it may be raised into contact with the screen/mesh.

Print direction forces to be applied on a screen/mesh **130** before print direction stretching are shown in **Fig. 14A**, and

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print direction forces present after print direction stretching on a screen/mesh **132** are shown in **Fig. 14B**.

Various options for the dual frame system of the present invention are shown in **Figs. 15A-15C**. In each case the screen/mesh is initially tensioned and fixed to a frame in the print direction. This is carefully done to eliminate any wrinkles in the screen/mesh and ensure a flat even surface. The fixed inner frame of the dual frame system may be attached to apply no additional lateral tension but to support the print area, and supply the ink barriers. As shown in **Fig. 15B**, the inner frame ends may include a raised level to minimize print direction contact. The fixed frame acts as a barrier. As shown in **Fig. 15C**, a simple push fit four piece inner frame assembly may be used for applying a set lateral displacement to apply fixed lateral tension forces. The end pieces may be fixed in top position, then pushed down into a locked position forcing the side pieces out a fixed distance. The side pieces are then fixed to the screen/mesh and are locked in position until they are removed from the screen/mesh.

Referring to **Figs. 20A-30**, another dual frame system option is a multi-piece frame with additional ink barriers. This arrangement is the most flexible dual frame system because it allows multiple frame sizes by using interchangeable side and end pieces. Different lateral tension settings may be applied by changing the difference in the length of the lateral supports compared to the end pieces. Interchangeable ink barriers allow

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the frame to be set to suit the press and the desires of the user. The multi-piece frame may include multiple side pieces, multiple corner pieces, and multiple end pieces. The pieces of the multi-piece frame may be configured in an interlocking format for a fixed frame. Interlocking enables a variety of frame sizes and formats to be easily produced. The multi-piece frame maximizes flexibility of frame dimensions and minimizes costs for frame production through standard sized component joints.

Multi-piece frame **200** has end frames **204** hinged to apply tension forces. The side frames pieces **202** are attached to a screen/mesh and the end frame pieces **204** are expanded via their hinges to apply tension laterally before being locked with a locking device **208**.

Several options are available for interlocking frame side pieces (see **Figs. 19-30**). The frame side pieces may be profiled to include ink barriers. They may be multi-piece to allow different frame sizes, and locks may be integral to the side pieces or be separate inserts. A mechanism **514** enabling the side pieces of the multi-part frame to be forced apart in fixed displacements for controlled lateral tension is shown in **Fig. 30**.

A tool **230** is shown in **Fig. 22** that has two prongs **234**, **238** enabling the simultaneous removal of two lugs from a corner piece **240** of an interlocking fixed frame. **Figs. 23A** and **23B** show cross sectional views of a side piece and an end piece of an interlocking frame. **Fig. 24** shows an end of a side piece **270**

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including an interlocking member **272**. **Fig. 25A** shows a corner piece **280** of an interlocking frame. **Fig. 25B** shows a cross sectional view of the corner piece **280**. **Fig. 25C** shows how the corner piece **280** may be configured in the form of a flexible corner piece. **Fig. 26A** shows a multi-piece frame with side and end pieces **302**, interlocking members **304**, corner pieces **306**, and straight locking pieces **308**. Views of ink barriers **310**, **316** are shown in **Fig. 26B**.

An inner frame side piece **600** is shown in **Figs. 31A** and **31B**. The inner frame side piece **600** includes a top bar **602**, a bottom bar **604**, center supports **606**, end supports **608**, and locking notches **610** in the top bar **602**. An inner frame cross support **620** is shown in **Figs. 32A** and **32B**. The inner frame cross support **620** includes a top plate **622**, a bottom plate **624**, and main plate **626**. An inner frame end piece **630** is shown in **Figs. 33A** and **33B**. The inner frame end piece **630** includes a top plate **632**, a bottom plate **634**, and a main plate **636**. Modifications to the inner frame cross section **650**, **660** are shown in **Figs. 34A** and **34B**. An inner frame assembly support clip **670** is shown in **Fig. 34C**. The clip **670** includes an end portion **672** with longitudinally extending portions **674**. The support clip **670** fits around the inner frame cross supports and the inner frame side piece end support. One may be included in each of the four corners and

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ensures that the side pieces and cross supports are held firmly together.

An inner frame parallel guide concept is shown in **Fig. 35**. The inner frame parallel guide **690** locking pin holes to provide positive placement, a width guide with optional dimension markers **692**, and a locking screw **694** for setting the width guide **692** setting. The locking screw may alternatively be positioned on the side of the parallel guide **690**. An inner frame side piece **700** with a profiled end is shown in **Fig. 36**. The profiled end **700** includes a bottom bar **702**, an end support **704**, a top bar **706**, and a profiled corner **708** in the top bar to assist end piece fitting. The top bar **706** also includes a locking notch **710**. The end piece may be fitted into the side recess to provide lateral tension perpendicular to the print direction. The forces required to pull a profiled end into a tension applying position depend on the frame size and the screen/mesh properties. For small frames, the forces may be applied manually. For larger frame sizes, mechanical and/or pneumatic assistance may be required.

A screen/mesh **810** following print direction stretching is shown in **Figs. 38A** and **38B**. An inner frame **826** placed on a print direction stretched screen/mesh **840** is shown in **Figs. 39A** and **39B**. An inner frame **856** fixed in position on a stretched screen/mesh **870** is shown in **Figs. 40A** and **40B**. An inner

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frame **886** fixed in position with end pieces **910** fitted in location on a stretched screen/mesh **900** is shown in **Figs. 41A** and **41B**. Lower level tension forces perpendicular to the print direction are applied to a screen/mesh **920** after an inner frame is mounted on the screen/mesh **920**, as shown in **Fig. 42**. A deflected screen/mesh **922** following the fitting of inner frame end pieces is shown in **Fig. 43**. A screen/mesh **948** with inner frame cross supports removed and end pieces locked into position with locking clips **944** is shown in **Fig. 44A** and **44B**. Once the inner frame is attached, the screen/mesh has been stretched, and the screen/mesh is ready for stencil application and imaging in a potential image area **972** (see **Figs. 45A** and **45B**). A screen/mesh **1010** with screen and ink/fluid barriers **998** in place is shown in **Figs. 46A** and **46B**.

A single-piece inner frame ink/fluid barrier structure **1030** is shown in **Figs. 47A** and **47B**. A corner structure **1040** of the multi-piece inner frame ink/fluid barrier structure is shown in **Fig. 48**. A portion of an ink/fluid barrier on a screen/mesh is shown in **Fig. 49**. Various ink/fluid barrier structures **1060** are shown in **Fig. 50**. Pre-coated screen/mesh properties are shown in **Figs. 51A-51D**. Additional screen/mesh support strips **1114** for lateral tensioning are shown in **Fig. 52**. Pre-cut screen/mesh

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pieces **1130** separated with protected layers **1140** for shipping and storage are shown in **Fig. 53**.

The following discussion explains the method for stretching and mounting a screen/mesh on a frame according to the invention. A new screen/mesh with a pre-coated stencil is prepared. The dual frame is prepared with adhesive tape (double sided). Minor lateral tension is applied to ensure the screen/mesh is flat and wrinkle free before clamping for stretching. The screen/mesh is clamped for stretching. The screen/mesh is stretched in the print direction. The second surface of the double sided tape is readied for adhesion. If available, the outer frame position is moved to ensure the stretched screen/mesh is central. The frame is raised to bring it into contact with the screen/mesh. Pressure is applied to ensure good bonding between the screen/mesh and the double sided adhesive tape. The tension is removed and excess screen/mesh is trimmed. The frames may be rotated 180 degrees for access to the upper non print surface of the screen/mesh.

The dual frame system is produced by assembling the inner frame. The two inner frame side pieces are fixed to the two inner frame cross supports and may be secured in position with four inner frame assembly support clips. Double sided tape is prepared and applied to the bottom bar of both inner frame sidepieces, and is not exposed on the free surface of the double sided tape. The inner frame parallel guide may be attached to each of the inner frame cross supports, as a pair on one of both sides of the inner frame sidepieces. The distance may be set

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from the outer frame inner edge for the inner frame parallel guides. The protective film may be removed from the double sided tape to expose the adhesive. The inner frame may be rotated so that the adhesive tape faces the exposed mesh, and the inner frame sidepieces are in the print direction. The inner frame may be lowered into contact with the screen/mesh, ensuring that it is centered and parallel with the outer frame sides (using the inner frame parallel guides if present). Pressure may be applied to ensure that there is a good bond between the screen/mesh and the tape. The inner frame sidepieces may be attached to a solid edge strip if the screen/mesh has a solid edge strip. This provides maximum contact area for adhesion and support between the inner frame and the screen/mesh. The inner frame parallel guides may be removed after stretching if necessary.

The inner frame assembly support clips are removed in preparation for the next stage. The first inner frame end piece with profiled corners is inserted inward to assist location, and pulled into contact with the end support on the inner frame sidepiece. The process is repeated for the second inner frame end piece. The four locking clips are inserted on the inner frame side pieces to secure the inner frame end supports in position. The inner frame cross supports are now loose, and are moved away from the end supports and rotated to allow removal. The inner frame is now installed and the screen/mesh tensioned. The inner edges of the inner frame sidepieces may be sealed with single sided adhesive tape to ensure that there is no fluid

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encroachment into the adhesive bond, particularly during the image washout part of the image preparation. The screen/mesh is then ready for use.

The four interlocking frame pieces of a four-piece frame system do not need prior assembly. The end pieces are configured to be in an upper non-tensioned position. The double sided adhesive tape is applied to the side pieces and exposed. The screen/mesh is already attached to the outer frame, and is checked to ensure that it is flat and wrinkle free. The side pieces are held, the frame is lowered onto the screen/mesh, parallel to the outer frame, and pressure is applied to seal the side inner frame pieces to the screen/mesh. Once bonded, pressure is applied to the end pieces, pushing them down until locked in position. This motion forces a fixed displacement of the side pieces outwards, applying lateral tension to the screen/mesh. This is repeated for the second end piece. The inner edges of the side pieces are sealed and ready for stencil application and/or imaging. Alternatively, the inner frame end pieces may be hinged and pulled into a straight position to apply the lateral tension.

A single piece dual frame system does not apply lateral tension to the screen/mesh, so the following procedure can be carried out before or after the stencil application and imaging stages of the process. This is possible because the single piece frame supports the screen/mesh and acts as the ink barrier, without applying any lateral tension, so it will not cause image distortion if applied after imaging. The screen/mesh is prepared, with or without the stencil and image applied. The

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double sided adhesive tape is applied to the inner frame side pieces and exposed. The screen/mesh is checked to ensure that it is flat and wrinkle free. The inner frame is applied to the non-print surface of the screen/mesh, parallel to the outer frame and central, and pressure is applied to ensure good bonding of the inner frame to the mesh. The inside edges of the side pieces are sealed and ready for stencil application and/or imaging, if not already completed.

The dual frame systems are applicable to both pre-coated screen/mesh pieces, with the stencil supplied already applied to the screen/mesh, and bare screen/mesh ready for stencil application. The pre-coated stencil simplifies the production process by eliminating this step and set of variables for the screen printer, but adds a registration and positional issue during stretching and mounting. For all of the dual frame systems, it may be applicable to apply the stencil before application of the inner frame. This simplifies access and makes the coating operation faster. The dual frame systems use conventional stencil application techniques for screen/mesh pieces that are not pre-coated. The stencil may be a photosensitive layer coated onto the bare mesh. Multiple layers of stencil may be applied and dried on a single mesh/screen ready for use.

The screen/mesh is now ready for imaging. A standard imaging process may be followed for conventional flat screens. Although not limited to this, one such procedure is listed below. The negative may be applied to the screen, locating it carefully.

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It may be exposed to a controlled amount and intensity of ultra violet light. The ultra violet light cures the exposed stencil, causing a physical change hardening and increasing resistance to removal. Areas not exposed to ultra violet light remain soft and water soluble. Any unwanted stencil materials may be washed out using water. The screen may then be dried. The process is completed in line with normal production procedures.

The screen/mesh is now stretched, imaged, mounted, and ready for final preparations. The ink/fluid barrier(s) are applied to the inner frame. Three categories of ink/fluid barriers include integral frame pieces that act as ink/fluid barriers, a single piece ink/fluid barrier construction with fixed screen image area dimensions, and a multi-piece ink/fluid barrier construction allowing a range of image areas and shapes to be considered. Each vertical barrier surface is sealed using single sided tape to ensure no ink/fluid leakage between the barrier components. There are four initial attachment techniques envisaged for the ink/fluid barriers to the inner frame. Velcro may be attached to the side and end pieces. Double sided (foam) adhesive tape may be attached to the top of the frame and matching surface on the ink barrier side and end pieces. Quick fit pin (or similar) registration and locking at the corners may be applied to the inner frame side piece. Liquid or spray adhesive may be used. With the ink barrier assembled and in position attached to the inner frame, its edges to the screen are sealed using single sided self adhesive tape, to ensure no ink/fluid leakage under

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the ink/fluid barrier(s). The screen is now ready to be used on press.

Snap off forces may be reduced and may need compensation. Natural snap off action due to the motion of a cylinder press mechanism does not pose major issues. Snap off ensures that this will be controlled by the print direction tension applied to the screen/mesh. If a problem occurs higher tension levels should be used. The support strip for the inner frame side pieces may also be of impact, with thicker support strips adding height for additional snap off. The choice of double sided adhesive tape to attach the inner frame to the screen/mesh may be selected to affect this, by use of a foam construction tape to increase the elasticity and snap back effect due to the tape. The squeegee action should be parallel with the frame side to ensure no lateral register problems. Squeegee setup may be simplified, with lower pressure levels required. More consistent and even squeegee deflection across the print width reduces density variation. Ink barriers hold the ink/fluid in place with a reduced open/spare screen/mesh surface due to the inner frame. The volume holding capacity of the screen/mesh may be reduced, resulting in the need for smaller but more frequent ink/fluid replenishment. Automatic ink/fluid delivery may be employed. Smaller ink/fluid volume ensures that the ink/fluid is regularly and consistently moved, improving flow properties and ink/fluid transfer uniformity.

Once printing is complete the screen/mesh is washed down as normal to remove all unwanted ink/fluid and debris. If needed to

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be used for the same image, the screen/mesh is then dried. The frame is stored in an appropriate rack system. Preference may be to store the frame and screen/mesh with the print direction of the frame vertically positioned. If the screen/mesh is to be reused for a new image, excess ink/fluid is removed from the screen/mesh and the screen is washed clean. The screen/mesh is removed from the press, and place in suitable location. The sealing tape is removed and disposed of from the ink/fluid barrier to the screen/mesh. The ink/fluid barriers are removed, and any ink/fluid residue is washed away so that the ink/fluid barriers are ready for reuse. The four locking clips are removed from the inner frame sidepieces. The two inner frame end pieces are removed. The two inner frame sidepieces are carefully pealed away from the double sided adhesive tape and the screen, starting in the corner, and using tape manufactures advised technique. Any excess double sided tape or adhesive tape is removed from the inner frame side pieces and the screen/mesh. The screen/mesh is exposed ready for stencil removal using conventional stencil removal techniques. The unwanted stencil is removed. The screen/mesh is ready once the stencil is fully removed. The new stencil layer(s) are mounted onto the screen/mesh using conventional stencil application techniques. The stencil is dried and ready for use. All of the inner frame components are checked to be sure they are clean and ready for use. The inner frame is applied following the procedure previously described. Note for the case of a capillary action stencil film, it may be attached after the inner frame is applied to the clean mesh.

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If the screen/mesh is to be disposed of, excess ink/fluid is removed from the screen and wash screen clean. The screen/mesh is removed from the press, and placed in suitable location. The sealing tape is removed from the ink/fluid barrier and disposed from the screen/mesh. The ink/fluid barriers are removed, and any ink/fluid residue is cleaned away, so that the ink/fluid barriers are ready for reuse. The four locking clips are removed from the inner frame sidepieces. The two inner frame end pieces are removed. The two inner frame sidepieces are removed away from the double sided adhesive tape and the screen/mesh, starting in the corner, and using tape manufactures advised technique. Any excess double sided tape or adhesive tape is removed from the inner frame side pieces ready for reuse. The screen/mesh is pulled away from the double sided adhesive tape on the outer frame, starting in the corner, and using tape manufactures advised technique. Any excess adhesive tape or residue is removed from the outer frame and clean ready for reuse. The outer frame is removed to a storage area ready for reuse. The used screen and adhesive tapes are disposed of in a controlled, consistent, and environmentally friendly manner.

The dual frame system described above is highly suited to the supply of individual screen/mesh pieces, supplied flat with a protective separating layer of suitable materials in boxes. The dual frame system simplifies storage, distribution, handling, and identification of screen/mesh samples and properties. The dual frame system also suits the use of pre-coated stencil, removes several pre-print stages in production, and improves stencil

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properties through industrial production. The system also simplifies the selection and use of optimum screen/mesh / stencil combinations for individual print jobs, specifications, and print applications.

The dual frame system only needs the screen/mesh stretched in the print direction simplifying the process, and significantly reducing the variables involved. However, in combination with individual screen/meshes, especially when pre-coated with stencil, new stretching systems that allow repositioning of the outer frame relative to the stretched screen/mesh prior to being fixed to the screen/mesh may be required.

In the dual frame system, the screen/mesh is attached to the inner frame on the outer edges allowing the screen to deflect evenly and consistently across the image width, without significantly greater resistive forces at the edges. This allows minimum squeegee pressures to be applied evenly across the width of the print image, reducing the squeegee wear, increasing squeegee and screen/mesh life, while producing a more consistent print result.

The dual frame system allows the elimination, if required, of the reclaiming of the screen/mesh material, by allowing removal of the inner frame from the screen for simplified stencil access and removal, or complete removal of the screen from the outer frame for disposal. Through the use of double sided self adhesive tapes, and similar techniques, the frame components are immediately available for reuse in the stretching and mounting of a new screen/mesh onto the outer and inner frames. In addition,

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the use of screen/meshes with the stencil pre-applied produces a more efficient, consistent, cost effective, and repeatable process, with high volumes of screen/meshes to recycle making the industrial recycling of the waste screen/meshes following disposal economically more viable.

The present invention is intended to provide a screen printing method and apparatus that assures reliable printing qualities, while offering the potential of a simplified production system by achieving disposable screen printing with woven screen/mesh materials.

While the invention has been described with references to its preferred embodiment, it will be understood by those skilled in the art that various changes may be made and equivalents may be substituted for elements thereof without departing from the true spirit and scope of the invention. In addition, many modifications may be made to adapt a particular situation or material to the teaching of the invention without departing from its essential teachings.

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